RISK MANAGEMENT AS U.S. NATURAL GAS TRANSPORTATION EXPLODES

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MASTER OF ENGINEERING IN SUPPLY CHAIN MANAGEMENT

MAY 22, 2018
AGENDA

• Introduction

• Literature Review
  • Natural Gas Market Outlook in the U.S.
  • The Natural Gas Supply Chain
  • The Current Transmission System
  • The Approval Process for New Pipelines
  • Why Pipelines are Needed

• Analysis Goals & Results
  • Pipeline Inflow & Outflow Capacity Utilization
  • Adequacy of the FERC Approval Process
  • Age as a Risk Factor

• Recommendations

• Appendix: Methodology Details
PROJECT PURPOSE

- Is pipeline capacity constrained?
- Is the FERC approval process for new pipelines efficient allocating capacity where it is needed?
- Are old pipelines a risk for accidents?

Map of U.S. interstate and intrastate natural gas pipelines

Source: U.S. Energy Information Administration, About U.S. Natural Gas Pipelines
PROJECT MOTIVATION

60% of all U.S. transmission pipelines installed before 1970

Shifting patterns in production and consumption

New projects proposed by individual companies – does that lead to an efficient network overall?
MY BACKGROUND

B.S. Chemical Engineering

3 yrs. Process Engineer
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U.S. NATURAL GAS PRODUCTION

Shale Gas Plays, Lower 48 States

Natural Gas Gross Withdrawals and Production

Source: U.S. Energy Information Administration
LITERATURE REVIEW – NATURAL GAS PRODUCTION FORECAST

NATURAL GAS PRODUCTION IS PROJECTED TO GROW 30% WITH SHALE GAS PRODUCTION IN THE EAST DRIVING GROWTH
LITERATURE REVIEW – NATURAL GAS CONSUMPTION FORECAST

CONSUMPTION IS ALSO EXPECTED TO GROW – (ACTUAL RATE NOT GIVEN)

GROWTH IS DRIVEN BY DEMAND IN INDUSTRIAL & ELECTRIC POWER USE
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LITERATURE REVIEW – THE NATURAL GAS SUPPLY CHAIN

- **Upstream** – geological exploration, drilling
- **Midstream** – processing (methane is separated from heavier hydrocarbons)
- **Downstream** – further processing (petrochemical) distribution
LITERATURE REVIEW – THE NATURAL GAS PIPELINE
SYSTEM

Upstream
- Gathering Lines
- Small Diameter 2-8 in
- Low Pressure

Midstream
- Transmission Lines
- Large Diameter 6-48 in
- 200 – 1500 psi

Downstream
- Distribution Lines
- Low pressure lines that deliver gas to customers
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LITERATURE REVIEW – THE NATURAL GAS TRANSMISSION SYSTEM

- Major Transportation Corridors
- Corridors from the Southwest
  - Southwest – Southeast
  - Southwest – Northeast
  - Southwest – Midwest
  - Southwest Panhandle – Midwest
  - Southwest – Western
- Corridors from Canada
  - Canada – Western
  - Canada – Midwest
- Canada – Northeast
  - Eastern Offshore Canada – Northeast
- Corridors from the Rocky Mountain Area
  - Rocky Mountains – Western
  - Rocky Mountains - Midwest
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LITERATURE REVIEW – THE FERC APPROVAL PROCESS FOR NEW PIPELINES

Pipeline Operating Company Submits Application
- Expected Costs
- Geological & Engineering Studies
- Rate Data for Pipeline Operation
- Environmental Studies
- Impact Analysis on Surrounding Communities

FERC Reviews the Market Need
- Historically has relied largely on pre-established contracts between a pipeline operator & a prospective customer to indicate market need

FERC Issues a Certificate of Public Convenience & Necessity
- Pipeline Company is granted Eminent Domain
- Construction can begin
- Company must make regular reports to FERC on their project status as well as changes to initial
Out of the 400 pipeline applications that have been filed since 1999, only 2 have been rejected.

Most of the approved capacity was planned for Texas and Louisiana.

There was no approved capacity in California and minimal in New England.
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### Table 6: Comparative Statistics for Petroleum Incident Rates: Onshore Transmission Pipelines vs. Road and Railway (2005-09)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Avg. Billions Ton-Miles Shipment Per Year</th>
<th>Avg. Incidents Per Year</th>
<th>Incidents Per Billion Ton-Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road*</td>
<td>34.8</td>
<td>695.2</td>
<td>19.95</td>
</tr>
<tr>
<td>Railway*</td>
<td>23.9</td>
<td>49.6</td>
<td>2.08</td>
</tr>
<tr>
<td>Hazardous Liquid Pipeline</td>
<td>584.1</td>
<td>339.6</td>
<td>0.58</td>
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<tr>
<td>Natural Gas Pipeline</td>
<td>338.5</td>
<td>299.2</td>
<td>0.89</td>
</tr>
</tbody>
</table>
STORAGE IS ALSO PROBLEMATIC

- > 1/5 of the 15,000 active underground storage wells are at risk for serious leaks. These wells comprise 51% of the country’s total working capacity, median age of 74 years.
- Some states, such as Florida have geologies that do not support natural gas storage.

- Aliso Canyon Injection storage capacity of 86 Bcf. Stored 63 percent of Southern California's natural gas.
- Leak detected in October 2015, stopped in February of 2016.
- Cost $1 billion, released over 100,000 metric tons of methane.
- Residents had high levels of uranium, lithium, and styrene.
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ANALYSIS GOALS

Calculate transmission pipeline utilization rates by state on a volume basis

- Inflow / Inflow Capacity
- Outflow / Outflow Capacity

Evaluate whether new capacity is being added in the right places

Consider age as a risk factor for accidents
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Export Utilization = Exports / Export Capacity
Import Utilization = Imports / Import Capacity
METHODOLOGY – IMPORTS & EXPORTS

\[
\begin{align*}
P &= 100 \\
C &= 75 \\
\text{Exp.} &= 25
\end{align*}
\]

\[
\begin{align*}
P &= 40 \\
C &= 60 \\
\text{Imp.} &= 20
\end{align*}
\]

\[
\begin{align*}
P &= 100 \\
C &= 75 \\
\text{Exp.} &= 25
\end{align*}
\]
METHODOLOGY – DATA SOURCES

- U.S. Energy Information Administration Website
- Production
  - Dry Production
- Consumption
  - Volumes Delivered to Consumers
  - Pipeline & Distribution Use
- Time Span 2011 - 2016
  - Consistent method of data collection
  - Consistent definition of state boundaries
  - 2017 data was not yet fully available
METHODOLOGY

• Production data was obtained from the EIA website
• After reading “Definitions, Sources & Notes” Dry Production was chosen for the analysis as it is consumer grade natural gas that would be transported in transmission lines
• Transmission lines were the focus of the later capacity analysis
METHODOLOGY

Natural Gas Consumption

- Consumption data was obtained from the EIA website
- To be consistent with the production analysis and look only at gas transported via transmission lines, I included “Volumes Delivered to Consumers” and Pipeline & Distribution Use
U.S. STATE-TO-STATE CAPACITY DATA

<table>
<thead>
<tr>
<th>State From</th>
<th>2017</th>
<th>Sum of Capacity (mmscf)</th>
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<tbody>
<tr>
<td>Alabama</td>
<td>20.687</td>
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</tbody>
</table>
PIPELINE CAPACITY UTILIZATION RESULTS - IMPORTS

States at Risk for Natural Gas Shortages
• Vermont
• New England in General
• Florida
• California

Reasons for Natural Gas Shortages
• Overreliance on Gas for Electricity (Florida, California)
  High Imports, Low or No Production
• Lack of Pipelines (Vermont, New England)

Consequences
• Resorting to Oil for Heat
• Power Outages
• NGL Storage Leaks
States Lacking Outflow Pipelines
• Pennsylvania

Reasons for Lack of Outflow Pipelines
• Old infrastructure, new production
• Environmental opposition to new projects

Consequences
• Limited production – wells drilled but not active
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ADEQUACY OF THE FERC APPROVAL PROCESS
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PHMSA ACCIDENTS DATA

- PHMSA Pipeline Accident Data: 2010 - Present
- 1001 Accidents Total
- Date of Manufacture: 1910 – 2015
- Causes of Accidents
  - Equipment Failure
  - Corrosion Failure
  - Excavation Damage
  - Material Failure
  - Natural Force Damage
  - Other Outside Force Damage
  - Incorrect Operation
  - Other
PIPELINE AGE AND RISK FOR ACCIDENTS

Average year of manufacture: 1965

3 out of top 4 Causes of Failure Related to Age
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CONCLUSIONS & RECOMMENDATIONS

- Natural gas production & consumption is likely to continue to grow
- Some states are currently experiencing capacity shortages
- Pipelines are safer in terms of accidents
- Pipelines appear to be better alternatives than storage
- Age & corrosion are major risks for accidents

- Either additional pipeline capacity should be added or production / consumption should be reduced
- Update the FERC approval process for a more holistic approach to supply & demand
- States should diversity energy sources and not become overly reliant on natural gas seeking quick “wins” in emissions reductions
Natural Gas Leaks in Boston

Propane Delivery in New Hampshire

Solar Production Unit tied to Gas Turbine in Florida

Natural Gas Well Pennsylvania

Methane exerts 86x the global warming potential of CO2 in the atmosphere during the first 20 years.
Northeast region slated for record natural gas pipeline capacity buildout in 2018 - U.S. EIA

Two-thirds of U.S. states may be putting their electricity consumers at financial risk because of an overreliance on natural gas. - Union of Concerned Scientists

'Golden age of gas' threatens renewable energy, IEA warns

Agency says tripling output by 2035 from unconventional gas sources such as shale gas could end support for renewables

Sunshine State Is Set to Get More Solar After Florida Ruling - Bloomberg
QUESTIONS?
RESULTS – NATURAL GAS PRODUCTION TRENDS

Seasonality: Production trends upwards from March through December and dips drastically in February

Largest growths occurred in:
- OH 1630%
- PA 449%
- ND 398%
- WV 329%

Largest declines occurred in:
- Fed. Offshore, GUFMEX 45%
- Montana 42%
- Louisiana 33%
- California 27%
- Kansas 26%
- Wyoming 22%
- Arkansas 22%
- Utah 21%
- Texas 10%
RESULTS – NATURAL GAS CONSUMPTION TRENDS

Seasonality: In most cases, delivery volumes increase after September, have the largest peak in January and decrease until May. Then there is a smaller increase with a local peak in July through August, and a decrease until September.

Largest growths occurred in:
- NC 70%
- VA 46%
- VT 40%
- DE 36%
- GA 35%

Largest declines occurred in:
- AK 34%
- ME 26%
- NH 17%
- RI 14%
- D.C. 12%
- KS 5%
METHODOLOGY – NATURAL GAS IMPORTS & EXPORTS

- Thought Process
  - For each state, how much natural gas would need to be imported or exported if each market was considered individually.

- Natural Gas Imports

\[
\text{IF Consumption} \ > \ \text{Production} \\
\text{THEN Natural Gas Import Volume} \\
\quad = \ \text{Natural Gas Consumption Volume} - \ \text{Natural Gas Production Volume} \\
\text{ELSE Natural Gas Import Volume} = 0
\]

- Natural Gas Exports

\[
\text{IF Production} \ > \ \text{Consumption} \\
\text{THEN Natural Gas Export Volume} \\
\quad = \ \text{Natural Gas Production Volume} - \ \text{Natural Gas Consumption Volume} \\
\text{ELSE Natural Gas Export Volume} = 0
\]
**METHODOLOGY – IMPORTS & EXPORTS**

**ASSUMPTIONS**

- All gas produced in a state is also processed in a state
  - Not always true. Typically < 5% is processed outside of a state

- Natural gas crosses state lines only once
  - Actual pipeline networks can be quite complex
  - A conservative and idealistic analysis

- All natural gas is can be transported in any available transmission line
  - All processed natural gas is of an average quality that meets pipeline specifications
  - In reality – pipelines can have inconsistent specifications

- Only processed gas is transported in transmission lines
  - No comment from EIA
From the capacity utilization charts, it is observed that Vermont had an average import capacity utilization of 70.38% for February of 2014.
STATES AT RISK FOR NATURAL GAS SHORTAGES

• Florida
  • 4th highest consumer of natural gas
  • 2nd highest importer
  • 62% of electricity generated from natural gas in 2015

• California
  • 2nd highest consumer of natural gas
  • 1st highest importer
  • 50% of electricity generated from natural gas in 2016